THE INCENTIVE SYSTEM OF AIRCRAFT MAINTENANCE ORGANIZATIONS

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The maintenance officer's interest in the efficiency of his operations is determined by the incentives that he faces. Though all organizations face unique penalties and rewards, common incentive pressures allow a statement of a general incentive system theory for aircraft maintenance organizations. The structure of the general incentive system is examined by considering resources inputs, the costs of these resources, and the services the organization performs as an end product.

The special problem of personnel utilization is closely considered. The Manhour Accounting System is criticized and a recommendation for an improved work study system is made.

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CHAPTER I

THE PROBLEM

A quotation concerned with the problems of military economic decisions suggests the subject and the approach of the analysis of Aviation Maintenance Organizations that follows:

> Efficiency in Military Decisions
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> . . . It is our conviction that something can be accomplished by (this) . . . approach alone--that is, by improved understanding of the nature of the problem--even without greater use of systematic quantitative analysis and with no changes in governmental structure. . . . If the alternatives are arrayed, and a serious attempt made to apply sound criteria in choosing the most efficient ones, decisions are likely to be improved even though the considerations brought to bear are mainly qualitative and intuitive.
>
> . . . .
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> Sound analysis, it might be noted, can not only help identify efficient courses of action but can also improve incentives. The existence of good analysis cannot alter penalties and rewards so that "what is good for the chief of each department is also good for national security" . . . (but) their existence . . . may increase the cost to decision-makers of making uneconomic decisions. . . . It should at least be possible to remove some of the perverse incentives injected by such factors as special constraints, the premium placed on getting budgets raised rather than using budgets more efficiently, and cost-plus-fixed-fee contracts. There must be some way to provide postmasters and depot managers with more appropriate motivations, as well as to improve the government's decision-making machinery.[1]

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[1]Charles J. Hitch and Roland N. McKean, <u>The Economics of Defense in the Nuclear Age</u> (Santa Monica: The RAND Corporation, 1960), R-346, pp. 107-09.

The incentive perversities that the quotation above considers are often recognized as present in a non-market economy such as the military establishment. Several authors have examined the general causes of this problem and have suggested the conceptual framework for analysing specific organizational incentives and rewards.[2] Beyond this, however, economists have not attempted to apply the principles they espouse to particular military organizations. It seems to me that is unfortunate because an "improved understanding of the nature of the problem" by military managers must have root in the specific environment of their organization. Broad economic concepts of efficiency become useful when clothed in particulars. Simon points out that classical administrative science has failed in "making operational the definitions of key variables and of providing emperical verification for . . . (its) propositions . . . ", and the same weakness will accompany any class of theories that does not move on to operational adoption.

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[2]Charles J. Hitch, "Economics and Military Operations Research" (Santa Monica - The RAND Corporation, 1958), p-1250, pp.10-12, 19-20.

Roland N. McKean, Efficiency in Government Through Systems Analysis (A RAND Corporation Research Study. New York: John Wiley and Sons, Inc., 1958), p. 8.

[3]James G. March and Herbert A. Simon, Organizations (New York: John Wiley and Sons, Inc., 1958), p. 33.

This paper deals with only the Naval Aviation Maintenance Organization. It attempts to state a general systems theory of the maintenance organization to assist the maintenance officer to abstract from the nature of his operations the properties of an individual problem. The nature of the organization is expressed as a function of the resources it uses, the costs or penalties it pays for its resources, and the services it performs as an end product. Several assumptions are made: First, the limiting factor of an aviation organization's ability to reach its objectives is its maintenance. The squadron or air station's resources of pilots, operations department and administrative department services, etc., are so plentiful that they do not act as a restraint on flight time. Since only the maintenance department limits the unit's output, we can ignore the other functions of the aviation organization when considering ways to improve the organization's performance. Second, assume that the management of the organization acts only in the best interests of that organization and that the personal incentives imposed on unit managers are the same as the incentives of their organization; managers are rewarded only according to the success of their squadron or unit. Third, the maintenance officer is the individual within the organization that controls the maintenance function.

Actually, all commanding officers reserve some authority from the maintenance that affects maintenance, but his decisions are passed to the maintenance officer for action, so we can view the maintenance officer as personifying the maintenance function.

Military systems design would be greatly simplified if designers could work with a clean sheet of paper. But, military systems changes have historically been piecemeal corrections to existing designs. The best designers have attempted to gain the improvement they desire with the least possible change, instead of rebuilding the entire structure. To make this type of change, it is necessary to start with a thorough understanding of the system as it is.

CHAPTER II

MEASURING THE ORGANIZATION'S OUTPUT

Hitch has generalized on the criterion problem as critical in an analysis of military organizations.[4] The maintenance officer faced with the problem of improving his organizational performance must first resolve what the organization is producing and how the product _is_ being measured. He must determine what constitutes better performance; he must choose a criterion or index that will indicate how well his organization is doing. It is easy enough to do this if he uses only his own satisfaction as an indicator. With his "feelings" as a guide, he has a continuous, very sensitive barometer for measuring the organization's output. He "knows" whether the safety program is operating well or poorly, whether the crew is dragging its heels, when quality control is not right, when morale is low or high, because his intuition is the measure of these things and, therefore, he is the best judge (only judge) of the current status of operations.

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[4]Hitch and McKean, _op. cit._, pp. 158-181.
Charles S. Hitch, "On the Choice of Objectives in Systems Studies", _Systems: Research and Design_, Donald P. Eckman, editor (proceedings of the First Systems Symposium at Case Institute of Technology, New York: John Wiley and Sons, Inc., 1961), Chapter 3.

Military intuitive judgement has been soundly damned by just about everyone, including most military men, and it is not necessary here to elaborate on its weakness. Not considering the compatability of the maintenance officer's intuitive criteria with national or other high level criteria, but only the interests of the maintenance officer, the major weakness of personal criteria is that they ignore the standards of excellence used by the next higher level of supervision to judge the organization's performance. To a great extent, "good" performance is defined by the particular Air Group Commander, Fleet Air Commander, etc., and the maintenance officer's criteria must adapt at least this higher influence.

This suggests another possible strategy for arriving at a workable criterion; use the criteria handed down by higher authority. If the Air Group Commander or CVA Commanding Officer says that a low AOCP rate, low accident rate, or high morale are his indices of a good squadron, then accept this as given and final. Certainly, self preservation requires that authoritative criteria must be used, whether it agrees with national or other higher level criteria or not, but this has several pitfalls for the maintenance officer. First, it is very difficult to determine exactly what criteria one's superiors are using. Squadrons and other aviation units have at least two bosses,

BUWEPS and an operational commander. Very often the directives from these two sources are in conflict and the unit management must choose between them. More often, the guidance given the unit is worded in "principles" or "broad policy" statements that are useless for definitive decision making and require the maintenance officer to make his own judgements. Also, the individuals assigned to billets superior to the aviation unit change, and the maintenance officer that relies on authoritative criteria will not find complete continuity from one individual to the next.

A third source of criteria for the aviation maintenance function is often espoused: high level national policy objectives. It is difficult to see how the maintenance officer can go wrong using such criteria as "military worth", "maximum national security", and "greatest possible efficiency and economy of operation" to measure his operational output. The trouble with this type of measure is that is is impossible to translate into useable low level standards. "Nobody knows precisely how (for instance), satisfaction, military worth, and national well being are related to the observable outcomes of various courses of action. We have not the models or the wit to translate those outcomes into such terms."[5] A blimp squadron commander

[5]McKean, op. cit., p. 19.

might view an increase of his airship allowance as in the national interest where CNO judges that the continued operation of even one blimp is an indefensable extravagance. Individual levels of authority do not judge the implementation of high level policy objectives in the same way, and criteria that use this language merely attempt to wrap intuitive criteria in sacred and unassailable justification.

A RAND Corporation Report[6] in 1958 considered the problem of a proper measure of effectiveness of an operational aircraft maintenance system. This report constructed a model of a maintenance unit using "Aircraft-in-Commission" time as a measure of effectiveness.[7] The author indicated that this criterion was not critically selected since the object of the report was to demonstrate a conceptual approach to model construction of production processes in which random variations play a major role. "Aircraft-in-commission" time, however, is in general use as a maintenance measure of effectiveness and demands close analysis in an investigation of useful criteria. By using aircraft-in-commission time, the effects of variability in the flight

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[6]R. A. Levine and R. B. Rainey, "Random Variations and Sampling Models in Production Economics" (Santa Monica: The RAND Corporation, 1958), P-1552.

[7]Appendix A diagrams the simulation model used for the study.

schedule and the weather are ignored. Using this model, the maintenance officer minimizes the total time that aircraft are waiting for maintenance. The aircraft with the least amount of work required is assigned the highest priority for work since it can be returned to an "up" status soonest. As the status of aircraft changes because of returning flights or delivered AOCP parts, personnel are shifted from longer jobs to jobs that offer a quick return of "in commission" time.

Naval aviation organizations have kept records of aircraft availability or aircraft-in-commission for some time. If this were a useful measure of effectiveness of a maintenance system, it would have certainly been universally adopted for judging performance by now. The fact is that it has not. The reason why lies in the division of objectives assigned to operating units. BUWEPS management control encourages the maintenance department of an operating unit to go about its business of repairing aircraft in isolation from the unit's operational objectives. The maintenance department's availability report, prepared for BUWEPS, is a statement of the aircraft in commission at a particular time each day. Similiarly, the RAND report indicated earlier totaled all aircraft-in-commission time. The BUWEPS availability reports essentially sample from the same data that the

RAND Study, in its experiment, measured totally. The use of aircraft-available time as the criterion for the measurement of maintenance performance assumes that the objectives of the total squadron or unit are optimized when the number of hours that aircraft are ready to fly is maximized.

This appears to fit well with higher level objectives for combat aviation units; maximum hours that aircraft are combat ready appears to optimize national security objectives.[8] But, the maintenance department cannot ignore the fact that it is supporting the flight operations of the unit, and the unit's operational objectives are stated in terms of flight time or number of completed missions. Further, though the influence of BUWEPS' incentives for "availability" are recognized, the operational incentives for "flight time" are much stronger.

The unit's operational tasks are established by "requirements" based on a "military judgement of needs"[9]

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[8]Or does it? Levine and Rainey, op. cit., in their discussion of the Aircraft Maintenance Model as largely controlled by random variations, point out that queuing models can be solved only for the steady state and the beginning of a war is not a steady state. Perhaps the peace time objective of Aircraft Maintenance is not "combat readiness" but rather "training", as measured by flight time.

[9]Hitch, P-1250., op. cit., p. 4, describes military judgement and the "principles of war" as rationalization of precedents and analogy, expressing nothing more than individual preferences and prejudices.

determined by superior commands and the unit's commander. Hitch points out that ". . . (to) prepare requirements on the basis of needs alone . . . is, of course, nonsense. . . . Some notion of cost, however imprecise, is implicit in the recognition of any limitation".[10] Most units find that the tasks required of them are always just a little bit more than they can produce; and when, by unexpected good luck or miscalculation, the unit does meet all tasks, it finds that its task level has been raised. To the superior command, controlling the utilization of the squadron, real costs to him do not vary with the squadron's output. He has no incentive to allow the squadron to decrease output, since the funds he has available must be either spent or lost. He gains nothing from returning unused funds. ". . . Cost . . . (is considered) as a limit . . . , not as a guide to efficient choice among alternatives and use of resources."[11] The squadron's output, then, is a free resource available to the operational command to fill its requirements. Because this resource costs him nothing, and contributes to his

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[10] _Ibid_. Contrast this analysis to Vice Admiral George C. Dyer, _Naval Logistics_, (Annapolis: United States Naval Institute, 1960), p. 17; "A "Requirement" doesn't change . . . just because of a lack of resources to support it."

[11] Hitch, _loc_. _cit_.

output, the commander "requires" the maximum amount obtainable.

Returning to the problem of the choice of the maintenance organization's measure of effectiveness, the organization must determine the output requirements on which its superior operational command bases performance evaluation. This is analogous to a board of directors evaluating a firm's performance only on the basis of the number of product units it produces, without considering the firm's cost in producing the units. Profit, or the difference between income and costs, is the measure of effectiveness of the firm. If the maintenance officer could view all of his inputs as free (i.e., had no costs to consider), as the controling operational commander does he would have no problem. The question of the maintenance officer's costs is considered at a later point.

Tasks of aviation units are always stated in terms of flight time totals or completed flight mission totals. Aviation units respond to this criterion rather than the criterion of aircraft-available time because the incentives imposed on the unit by the operational chain of command are exceedingly more powerful than incentives from BUWEPS or other sources. An aircraft ready to fly, but tied down in a hanger bay, has no utility to the squadron except as it will contribute to future successful missions. A

strategy of not flying at all would optimize the maintenance organization's record of aircraft-available time. In fact, some maintenance organizations develop a resistance to flight operations based on the feeling that operations are "hurting" maintenance's record, as if the two functions had divisible objectives. The maintenance organization is successful only as the entire unit is successful. When measuring the effect of alternate policies on his system's output, the maintenance officer is obliged to use operational objectives as his best measure. Perhaps if BUWEPS wrote his fitness report instead of an operational commander, this would not be true.

The choice between "aircraft-available time" and "flight-time" would be unimportant if the two were empirically correlated. The writer's experience has been that they are not correlated and the maintenance officer can waste a lot of energy chasing the wrong index. There are several ways that the maintenance officer can improve his "availability" record without improving the unit's flight time output; juggling the flight schedule and winking at inaccurate reports are examples. More serious is the incentive for resisting flight operations that the "aircraft-available" index creates by insulating the maintenance department from the organization's objectives. A situation common to carrier aviation operations illustrates

the point well. Maintenance work typically is generated in "lumps" because several aircraft must operate together and, therefore, return together. To optimize "aircraft-availability", the aircraft that do not require repair work, only fueling and other servicing, would receive priority attention because they can be made "available" soonest. But, if the maintenance officer desires to provide the maximum number of ready aircraft for the next scheduled launch, priority is assigned to the aircraft needing the most extensive repair that may possibly be completed in time for the launch. The more certain that an aircraft will be ready on time, the more slack its priority will be. This policy is much more difficult to use because maintenance crews must be shifted between aircraft often and this complicates work scheduling.

A second reason why the two indices loosely correlate springs from the complexity of modern aircraft. A significant percentage of aircraft reported "up" by maintenance develop trouble before being launched. Maintenance cannot check each of the aircraft's systems before releasing it for flight; reported troubles are repaired and it is assumed that the aircraft is available for flight. Often there are checks and precautions that could be made by maintenance personnel that would reduce the number of undiscovered discrepancies that later prevented launch. Use of

these checks and precautions is discouraged if the maintenance function is measured by "aircraft-available" statistics.

The case for using flight time as the measure of effectiveness of the maintenance organization can be summarized as follows: It is a statistic that is easy to acquire. It is the measure of effectiveness used by superior operational commands to judge the unit's performance. It encourages the maintenance function to adopt the objectives of the organization as its own. It is the best index available for making unit objectives compatible with high level objectives of military worth, readiness, etc., assuming that flight time is a good measure of the degree of training of pilots and maintenance crews and of the physical condition of aircraft. The greatest failing of flight time as a criterion is that it ignores costs. This impinges on national objectives--the real cost of the last hour of flight time may be more than its military worth to the nation. The nation's costs are different from what the maintenance officer views as costs.

CHAPTER III

THE ORGANIZATION'S RESOURCES

The operational aviation maintenance system is distinguished most by the rigidity of the inputs available to the maintenance officer. The activity organization has been designed to minimize the manager's discretion in varying inputs into his system. In theory, the maintenance organization should be able to "run itself". The personnel and aircraft allowances are fixed and take years to change; the technology and procedures used by the organization are given in detail and prescribe exactly the material and tools to be used; and the intensity of operations is determined by the flight schedule prescribed by the unit's operational command. Who <u>needs</u> a maintenance officer?

<u>Human Resources</u>. A closer look indicates, however, that there are areas of flexibility in inputs that allow the maintenance officer to affect the unit's performance. The first of these is the human resources available to him. The number of personnel assigned and their prior training are largely beyond the control of the maintenance officer, but the manhours expended by the work force and their current training are controllable. Human resources contribute effort and skill to the organization's output. Too many Navy and industrial managers consider the crew's

effort the only variable human resource output available and ignore the possibilities for increasing skill. For instance, a Northrop Corporation study[12] indicates that employees' effort has the greatest impact on a company's human resources output. The study concluded that "improving employee effort" offered as much opportunity for savings as "improving mechanical methods" and "reducing idle time" combined. This paper, however, will not consider the employee effort problem for two reasons: First, the study of motivation of human effort has occupied the attention of military managers for a very long time. Both the problems of motivation and techniques for accomplishing it are the subject of leadership. Certainly, the study of leadership can still pay dividends to the Navy manager, but there are other areas just as profitable which have been largely ignored.

The second reason why this paper will not consider the problem of effort is because the Navy pattern of motivational systems is fixed, it is reasonably successful, and it is not available for change during the short run. By "motivational systems" is meant the Navy's procedures and tradition for performance evaluation, promotion, pay,

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[12]Northrop Corporation, "PACE Manual" (Beverly Hills: Northrop Corporation, 1959), p. I-3.

rank structure, etc. An officer faced with the problem of improving a particular operation cannot expect to be able to change these systems, though he may have influence in long run improvement of them.

But, the skill of the maintenance officer's human resources also contributes to his output. Like sobriety, everyone speaks well of training but finds that it just doesn't fit their circumstances. Effort and skill can be largely substituted for each other and probably the costs of increased skill, in most organizations, are much less than the costs of increased effort, for the same return in output. More training, then, can have a higher payoff than more leadership or motivation from the same human resources.

Work Methods. Work methods of the maintenance organization have a major influence on output and are often under the maintenance officer's control. Two categories of work methods must be recognized. First, there are the methods that generally are the subject of industrial motion and time study.[13] The maintenance officer has very little knowledge of, or control of, the specific motions that constitute the tasks of the various technical ratings of personnel assigned to him. Whether this

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[13]Ralph M. Barnes, Motion and Time Study (fourth edition; New York: John Wiley and Sons, Inc., 1958), chapter 3 describes the types of studies in which time and motion study techniques are useful.

arrangement is the best possible, or not, the maintenance officer does not often involve himself in <u>how</u> to pull an aircraft engine or disassemble a generator, for instance. The maintenance officer can help his performance by arranging training that improves his crew's knowledge of the prescribed methods for technical tasks, but the methods are rigidly controlled by BUWEPS (through technical manuals and directives and the training of enlisted ratings) and are not available for change by the maintenance officer. This fact has considerable meaning when comparing the function of the aviation maintenance officer with that of the standard industrial activity manager. This means that time and motion study techniques, a subject of elemental importance to the industrial manager, have almost no utility to the maintenance officer. Undoubtedly, many of the methods prescribed by BUWEPS could be improved by time and motion study, but the maintenance officer does not find it profitable to expend a major effort for this purpose because his influence on task methods is small.

A second category of work methods, however, is under the maintenance officer's control. Though he accepts <u>how</u> the task will be performed as given, he controls when and where the task is performed, and by whom. The types of methods he can control include personnel utilization, scheduling, work flow, procedures for inter-task

coordination, and support functions. In this area many of the supervisory tools associated with industrial management are useful to the maintenance officer. Gantt Charts for work scheduling and check lists for standardization and work analysis are commonly used by maintenance activities.[14] Work analysis techniques such as flow diagrams and process charting are less commonly used by maintenance activities, but could be profitably employed. The Work Study Group, Pacific, used work flow diagrams in designing the layout of the Lemoore Naval Air Station Maintenance Department Tire Shop with excellent results.[15] Process charting of functions such as material requisitioning and sequencing of the elements of periodic aircraft checks offers the maintenance officer major improvement of his procedures.[16] The construction of methods for controlling the activity's work scheduling, process flow, and personnel utilization is a major input to the aviation maintenance function, and it is a variable that the maintenance officer can control.

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[14]Marvin E. Mundel, Motion and Time Study, Principles and Practice (New York: Prentice-Hall, Inc., 1955), pp. 36, 142, 181-82, provides examples of uses of check lists in work analysis.

[15]Pacific Fleet Work Study Group, "Aircraft Maintenance Department, NAS Lemoore, California" (Fleet Work Study Report No. 9A, NAS Lemoore, 1961).

[16]Barnes, *op. cit.*, chapter 5.

Unlimited "Free Goods". A third aviation maintenance input is the consumable material that the maintenance department draws directly from the Navy supply system. These material include repair parts, hand tools, lubricants, general supplies, and fuel. Within broad limits, the maintenance officer may view this material as a free input; he is not bothered by a scarcity of this material. Activity budgets of funds to pay for this material (except repair parts, for which he has no budget) are based on average cost per flight hour. Since fuel costs dominate the hourly average, changes in maintenance expenditures can only slightly affect the budgeted funds. Almost any tradeoff of this class of material for manhours that is technically available to the maintenance officer will be profitable to him. As a rule, the squadron does not pay a cost or penalty for using this material until its usage becomes significantly higher than expenditures of other squadrons operating the same type of aircraft. When comparisons between units are difficult, because the aircraft is new to the fleet or operating conditions for one unit are unique, the maintenance officer's freedom for expenditure variation is increased. Similarly, there is practically no incentive for reducing expenditures. The unit that attempts to improve its performance rating by conserving material of this class must make extremely large reductions

to distinguish itself, and often gives the impression that it is not performing functions that it should be performing. Within the institutional restraints on the issue of this class of material (i.e., "turn in one to get one"), the maintenance officer can use this material in any manner that optimizes the output of his scarce resources such as aircraft or personnel. Probably, very few tradeoffs using this class of material will remain available to the organization at any one time because most units operate at the technical limit of exchange. Most people in the organization understand and recognize this type of opportunity very well.

Limited Allowance "Free Goods". The fourth class of inputs to the maintenance function is semi-fixed capital equipment, such as ground handling equipment, maintenance spaces, and heavy shop equipment. Items of this sort are intended to be controlled by rigid formulas that guarantee equal treatment of all units. Usually the item is issued and controlled by an air station or other service activity not in the unit's chain of command. Many maintenance officers find, however, that negotiation or friendship can often bend these rigid controls.[17] For instance, effective

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[17]Hitch & McKean, *op. cit.*, p. 164, comment on the use of negotiation, "cooperation and coordination" as a replacement for a market mechanism to gain efficiency in the distribution of resources in the government.

documentation of a "need" for additional hydraulic jacks or other support equipment will often gain the equipment for one unit while undocumented needs in other units remain unfilled. Also, the interpretation of issue formulas is often negotiable and offers the maintenance officer opportunity to increase his input of this class of equipment. Services performed for the unit by support activities, such as repair parts delivery and Class A, B, and C level heavy maintenance services, can often be expanded by the maintenance officer if he carefully interprets the directives that control these services. Very often ground handling equipment, and other items of this class, can be substituted for a significant number of manhours. Where this opportunity is available, the maintenance officer can realize an important increase to flight hour output, or reduce the crew's work effort, by effective negotiation. Obviously, increased utilization of equipment of this class assigned to the unit has the same effect as obtaining additional items. Maintenance and scheduling procedures for the equipment will effect their utilization. The design of these procedures can be considered part of the work methods input discussed above.

The Limiting Resource. The last system input is fixed in quantity and extremely difficult to change. This is the number of assigned aircraft, the most important

asset the maintenance officer has. Very dramatic changes in output could be realized if he had control of aircraft assignment. Its importance justifies very close survaillence of the unit's on-board count versus allowance and any opportunity to increase aircraft will pay significant dividends. The aircraft assignment determines the range of output within which the most efficient and least efficient maintenance officer must operate. As a rule, though, the maintenance officer cannot influence these allowances and must plan his operation with the assumption that aircraft are fixed.

CHAPTER IV

THE ORGANIZATION'S COSTS

After considering the types of inputs into the aviation maintenance system, we are now in a position to discuss the costs of these inputs. In this context, the cost of any particular input to the individual organization can be quite different from the cost of the same input to the Navy Department. "Most of the cost of poor decisions does not fall on those who make them. The incentive to seek profitable innovations and efficient methods is not a strong one."[18] Higher level costs will be discussed below.

Costs are ". . . those negative effects (of an action) which we like to decrease."[19] The maintenance officer's only significant costs are human resources. The word "morale" is often used to describe the work force's long-term productivity to the organization and to the Navy. "Morale", however, is concerned only with long-term effort and does not include the long term consequences of training or the failure to train. The negative consequences on later skill and effort as a result of the

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[18]McKean, op. cit., p. 8.

[19]Hitch and McKean, op. cit., p. 165.

maintenance officer's actions are the only costs which the organization pays.

Consider the nature of inputs into the organization as that organization views them. Fuel and spare parts are essentially free; there are no repercussions to the organization for any changes in consumption, within broad limits. Allowance list items such as heavy equipment, working spaces, aircraft, etc., though difficult to increase, cost the organization nothing. It cannot receive a "gain" by returning any of these items and does not suffer if it is able to increase its input of them above the set level. Since the unit loses nothing and usually can gain something by increases, it logically must continually press for more. This is not true of the human resources categories. Increased use of these must be paid for from within the unit. The maintenance officer cannot pay a bonus or overtime for greater effort from his crew. The same is true of work method changes that disrupt the crew's habits or disturb the security of their work routines. Training costs the organization immediate output with the expectations that later output will be greater. In summary, the manner in which human resources are used in any time period by the organization produces consequences for the organization in several other time periods which must be recognized. The use of all other resources has

consequences for a single time period only.

Admittedly, human resources costs are very difficult to measure. Many Navy managers are able to defer this cost for long periods. Authoritative control of the crew can effect his productivity, but, if no sooner than the expiration of enlistment, the unit pays sooner or later in undeveloped skills, disciplinary problems, and uninspired willingness to work. All organizations are evaluated by these types of records to some extent. It is important to the maintenance officer to carefully consider the manner in which his organization is evaluated on this cost when he is formulating operational strategy. Increasingly, superior commands are providing considerable incentive for their unit's to demonstrate increasing reenlistment rates and decreasing disciplinary cases. If these things have real value to the unit in terms of its performance rating, then the unit can consider trading flight time output to gain them. Often, however, the unit rating cannot be improved more, once it has attained a certain level of reenlistment, for instance, and diverting resources from flight time output to further improve the unit's reenlistment rate is a waste of resources. Since reenlistment and discipline indices do not directly measure morale, they exhibit a range of randomness which is extremely costly to control. Also, the

crew's willingness to produce is not fully measured by these two records. Often, present flight time can be profitably reduced to increase the crew's long term productivity without being reflected in the reenlistment and discipline records. Superior commands attempt to evaluate this factor with Administrative/Material Inspections and other forms of audit, but with limited success.

It was suggested in the discussion of a proper measure of effectiveness for aircraft maintenance organizations that "flight time" or "completed missions" should be used. The unit's "cost" of human resources argues against this measure by itself. At some point the gain of additional flight time is not worth its cost to the organization in future skill and effort. If the maintenance officer could somehow reduce human resource costs and flight time to a common unit of measure, he could use the difference between the two as a measure of the desirability of different courses of action. If a policy under consideration added more to flight time than it cost in human resources, it would be profitable to use that policy.[20] Under the present incentive system, then, the maintenance officer's problem is the impossible one of finding an accurate measure of human resources costs and equating it to flight time.

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[20]Ibid, p. 175

But the effort to define this problem has not been wasted for several reasons. First, the concept of the maintenance organization as an integral system with a single, measurable output can be extremely valuable for evaluating alternative policies and procedures. The concept provides a filing system of categories in which effects of plans being considered can be sorted.

Secondly, many alternatives arise which affect either flight time or human resources, but not both.[21] If the maintenance officer can increase the crew's skill without reducing flight time output, by a procedural change, the organization gains on balance. In the other direction, an opportunity to increase flight time, without requiring the crew to exert more effort, is a very easy decision. More often, though, alternatives that will increase flight time also increase human costs. There is a broad range of this type alternative that is not a problem because the difference in magnitude of gain and costs is large and easy to judge. Inescapably, however, problems arise in which the net gain of proposed alternatives is difficult to determine. It is important for the maintenance officer to realize that his difficulty is a result of an inability to accurately measure his only cost, human

[21] Ibid.

resources. The effect of his decision on this cost, and on flight time output, should be the core of his analysis. No other considerations can be more revelant to the organization's performance than these.

CHAPTER V

PREDICTABLE BEHAVIOR OF THE ORGANIZATION

The discussion above has tried to ignore the multiple variations of incentive climates that aviation organizations encounter and distill the organizational pressures that are common to all. All organizations are influenced by BUWEPS maintenance material requisition procedures and standard operational controls that contribute to the incentive structure that determines the organization's behavior. Specific organizations must live with other influences that are peculiar to its organization. If the air group commander writes his squadron Commanding Officers' fitness reports with the Happy Hour Attendance Record or "Alfa" fund expenditure records before him, then, obviously, the squadron is well advised to trade a little flight time for Club time or efforts toward holding down administrative expenses. But, it is impossible to generalize on this type of performance criteria except to recognize that it exists.

One other influence commonly observed in organization behavior that has been ignored by the discussion above is the maintenance officer's sense of duty to broad Navy interest and not just the interests of his organization. Again, it is only possible to recognize that this influence

exists in most organizations. Since variation in the strength of the influence and individual interpretation of "the interest of the Navy" is so wide, it is fruitless to attempt to generalize on its impact on organizational behavior. Consider the problem of spare aircraft wheels and tires held by a squadron. Supply directives state that squadrons will not keep any spare wheels and tires in their possession, outside the supply facility, because this greatly multiplies the inventory costs of these items. The squadron gains an occasional extra hour of flight time by having spare wheels and tires available right on the flight line instead of in the auxiliary store in the hanger. The "interests of the Navy" appear to be served by not keeping spares on the flight line, but it costs the squadron nothing to exchange the wheels and tires of a stricken aircraft, for instance, for good spares that can save hurried twenty minute trips to the store. Maintenance officers see their duty to turn in spares in different ways. Some units will hold none; others will hold enough to optimize flight time, but not enough to optimize the convenience of the crew. A few will hold as many as it can get until the quantity becomes a nuisance to the crew.

It is suggested that the assumption an organization will not behave as if motivated by broad national or

service interests is very useful when designing information or control systems. This assumption implies that the organization usually behaves as if optimizing its own interests as determined by the incentives it faces. If the design of a control system can align the objectives of the system with the interests of the organization, it will be much more effective than if the system establishes special incentives or relies on a "sense of duty" to the Navy.

There are a great many control systems in use in aviation organizations that are based on special incentives other than the operational objectives of the unit. Enlisted promotion examinations and correspondence courses, leadership programs, safety programs, and service information programs are examples. These systems cost the squadron effort, but do not contribute to its worth directly. The high rate of personnel turnover in the organization encourages the organization to evaluate its own actions and alternatives on a short term basis, usually two to three years. Actions which have a payoff longer than this period will not be undertaken by the organization without special penalties or rewards High level authorities that judge a particular system to have long range worth, then, must create special incentives to control the organization's behavior in the manner desired. It is

very difficult to judge the proper strength of special incentives to elicit the exact behavior desired and not create unexpected spillover effects on the unit's primary objective. The problem is avoided if the system can be designed to contribute to the organization's worth.

In addition to long range objectives, special incentives are used by higher authorities to express their judgement of the short range worth of particular actions. An organization seeking to optimize the difference between flight time and its human resources costs will seek an AOCP rate or accident rate, for instance, that optimizes this value. As an example, the organization will tend to find a level of support equipment preventative maintenance or aircraft cleanliness that balances flight time gain and effort cost. If higher authority determines that this balance is, in fact, a poor solution to optimize the organization's worth, it must use a special incentive to change the organization's behavior. Many times, where objectives extraneous to the organization are not involved, the organization will generally produce a very good balance, and higher authority often prescribes an inferior one. Thus, arbitrary work uniform regulations and work space cleanliness standards must often be renegotiated to a more "reasonable" level.

If aviation maintenance units operate under

the conditions described above, the maintenance officer will replace labor with fuel, repair parts, or any other free resource until he has exhausted the prescribed budgets available to him or until no other possibilities for substitution are available. Because he must later "pay" for the way in which he uses his human resources, the maintenance officer profits from any procedure that reduces his crew's effort or increases their skill by using more of the "free" resources available. Further, since some resources, though free, are limited (support equipment, aircraft, etc.), the maintenance officer will profit from always using the full amount of these resources available to him. For example, he will always requisition the maximum quantity of support equipment available to him, as long as the last piece of equipment he received has positive value. Similarily, he will substitute less limited resources for more limited resources when this is technically possible.[22]

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[22]M. W. Hoag, "The Relevance of Costs in Operations Research" (Santa Monica: The RAND Corporation, 1956), P-820, p. 11, cites an example of a military commander that used coffee as a sweeping compound because the allotment from which he bought coffee was loose while the allotment from which he bought sweeping compound was tight. If he was overallocated coffee to the point that it had to be thrown out, use as a sweeping compound is an "efficient" use of coffee. Probably the commander could not even guess at the relative costs (to the government) between compound and coffee--both were "free goods".

The design of a price-budget system for operational units has recently received much attention in the Navy. It appears certain that before long a new accounting system[23] will be installed, designed to identify all expenditures incurred by operational organizations.[24] The question of the system's success in encouraging efficiency is not solved by simply identifying all expenditures, however. The word "efficiency" is often used in the military to mean the absence of redundancy or waste of resources used toward an objective. The concept of "efficiency" should include the mix of resources used. Efficiency in the mix of resources used by operational units has been defeated in the past by allowance lists which control the issue of each item independent of all other items. The "true" cost of an item to a unit is what must be foregone to obtain the item. The maintenance officer is very limited in his ability to exchange types of resources. He is assigned a specific number of tow bars and hydraulic jacks. He cannot forego a few jacks in order to get more tow bars as he could if he were in

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[23]Department of Defense Instruction 7040.1.

[24]Hoag, loc. cit., argues that any cost index has problems, but that "estimated money costs" is the "least unsatisfactory" base for costing military operations (vs. manhours or other "real terms").

the market place. This lack of substitutability is what causes the maintenance officer to view his resources as "free goods". If he had available a money budget from which he had to purchase all of his resources, he would not "buy" more jacks if tow bars were more valuable to him. The cost to the organization of an item purchased would be determined by the utility of the other items it is necessary to forego. If the unit can afford either jacks or tow bars, and buys more tow bars, their value is the jacks it must do without. Under an item allowance system, the maintenance officer can choose only between "jacks" and "no jacks" and, unless he already has so many that more of them would only be a bother, he will invariably draw the jacks. If the faults of the "free goods" system are to be corrected, improvement must start by increasing the maintenance officer's options for substituting between resources.

A great many military writers have bemoaned the tendency to centralize decision making at successively higher levels in the service hierarchy. They argue that the local commander is in the best position to determine his "needs" and can therefore provide the most efficient solution to the resource mix for accomplishing its tasks.[25]

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[25]J. H. Garrett, "Characteristics of Usage of Supply Items Aboard Naval Ships and the Significange to Supply Management" (Navy Management School paper, Monterey, California, 1961), p. 12.

This argument for decentralized decision-making is essentially the same argument made in the previous paragraph. It is valid if two assumptions are valid: first, the decentralized authority evaluates the costs of the resources he uses in the same manner and over the same time period that higher level authorities value the same resources. Second, the decentralized authority views his objective in the same way as higher level authorities.[26] Obviously, neither of these assumptions is entirely valid and the problems involved in making them valid do not have any easy solutions. Further, military commanders have tended to view the advantages of decentralized authority as ending at their particular level in the hierarchy. Thus, fleet commanders insist that they should control their air logistic support, but accept the "fact" that they must ration the use of that support by subordinate ships and other units.[27] The argument for decentralized authority is valid down to the lowest production center, but the

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[26]Hitch, op. cit., p. 21. "Criteria at decentralized decision levels (should relate) . . . with incentives and information at the same levels. It does little good to ask a subordinate official to maximize a function requiring data he cannot get, or one that runs counter to his self-interest. . . . Incentives, as in the market economy, can make or break any plan."

[27]Garrett, op. cit., p. 17. "It seems a perfect analogy (to decentralized business management) to me to look upon a task fleet commander as the very highest point at which similiar decisions should be made regarding . . . military readiness."

problems incurred because of "proximate criteria"[28] for measuring costs and stating objectives multiply at each level as authority is pushed down into the hierarchy.

[28]McKean, op. cit., chapter 2, "The Criteria Problem." i.e. "Proximate criteria" for translating words like "optimum", "adequate", and "minimum possible" into observable outcomes.

CHAPTER VI

CONTROL OF PERSONNEL UTILIZATION

It has been pointed out that the maintenance officer's only costs are in human resources (the only resource which, when used, has later undesired consequences for the organization). Also, personnel is the only resource with which the maintenance officer has a degree of freedom to determine the manner in which it is utilized. For both of these reasons the maintenance officer has a strong interest in an information system that will give him useful informationof how his crew is being utilized.[29] This appears to be the purpose of the Manhour Accounting System of BUWEPS Instruction 5440.2[30] This system requires all shop supervisors to account for the working hours of their crew by specified categories of productive and non-productive time.[31] This data is compiled for the entire department and displayed to the maintenance officer to

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[29]Appendix D distinguishes between a performance evaluation information system and a personnel utilization information system.

[30]Bureau of Naval Weapons Instruction 5440.2 dated 23 September 1958. Section G, Manhour Accounting is reproduced as Appendix B.

[31]Appendix B, p. 49,

assist him in:

> . . . planning and workload scheduling; in man power distribution; in pointing out time consuming practices, especially in non-productive areas, and in providing a basis for justifying realistic personnel allowances.[32]

These functions correspond to the "work methods" input to the maintenance function discussed earlier. Appendix B is a reproduction of Section G, Manhour Accounting of the BUWEPS Instruction and Appendix C is a criticism of several aspects of the system.

The Manhour Accounting system appears to suffer most from one inaccurate implied assumption. It assumes that the work or job of each man and each shop is "carved in cement"; that is, the proper function and output of each man is (or can be) predetermined and the purpose of an information system is to merely indicate to the maintenance officer where humans are not performing "as they should". In his criticism of "Classical" Organization Theory, Simon says "to understand the formal theory, it is important to recognize that the total set of tasks is regarded as given in advance."[33] Exactly the same weakness appears in the concept of Manhour Accounting. Even with an accounting report of great accuracy before

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[32]Appendix B, p. 45.

[33]March & Simon, <u>op</u>. <u>cit</u>., p. 23.

him, the maintenance officer is still stuck with the problem of determining where his figures vary from what "should be" and what "should be" done to correct the variance.

If an information system is to assist the maintenance officer in the utilization and control of his personnel, it must face up to the fact that the maintenance function is extremely random and largely undefined as to subfunctions that must be performed. Every new aircraft shifts the functions of at least some of the technical ratings assigned to the department. A newly formed squadron, with a new type aircraft, spends most of its training period deciding what functions will be performed by what shops or ratings. Aviation ratings have expanded and contracted wildly during the past few years as new aircraft change the functions performed within the maintenance organization. Similiarly, the random nature of aircraft systems discrepancies makes predetermined functional assignments extremely difficult. The "proper" personnel allowance for the ordnance shop, for instance, is impossible to determine until the organization has generated some experience with the weapons systems of its aircraft, flying specified missions.

The Manhour Accounting System, then, has failed to be useful to <u>any</u> maintenance officer because it was designed to be used by all of them. Since the functions performed

vary widely between organizations, it is impossible to develop a universal set of observation categories that will have meaning for all units. The industrial engineering literature concerned with work analysis suggests that industrial firms have encountered the same problem. "Very definite specifications are generally laid down for details of observation, but only vague specifications for data analysis."[34] There is no theory of work that will apply to all work situations, so work study theorists, unable to generalize on work analysis, have been limited to developing intricate mechanical techniques for gathering data to be used after the objectives of the particular study have been given. The work of Heiland and Richardson,[35] as an example, is the best known exposition of the work sampling technique for work study. They handle the problem of the way in which work sampling can be used in this language:

> The preceding uses of Work Sampling are expressed in broad terms. This is done in order that in the setting of objectives of Work Sampling, the uses may serve as suggestions and as a guide, rather than as a "cookbook" set of rules. Each situation in which the technique is applied is different. However, those applying Work Sampling are much better situated than anyone else to appraise their own individual

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[34] Ibid., p. 16.

[35] Robert E. Heiland and Wallace J. Richardson, Work Sampling (New York: McGraw-Hill Book Company, 1957)

> needs. In addition, those on the scene must live with the results, and should choose objectives which are practical to the particular activity to be studied.[36]

Ignoring the experience of industrial analysts, the Manhour Accounting System not only defines the technique for aviation maintenance work studies, but also attempts to define the studies' objectives by prescribing the work categories to be observed.

If the above analysis is correct, BUWEPS could improve the Manhour Accounting System by making it a simple technique for studying any work problem and allowing the unit maintenance officer to define his own problems on which the technique is used.[37]

This would involve providing the maintenance officer with a capability for making work studies, replacing the Manhour Accounting System, and accepting the fact that the usefulness of this capability, to both the maintenance officer and higher authorities, depends entirely on the nature of the problems in his organization. The best technique for studying work problems in randomly variable operations that is currently on the industrial

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[36] Ibid., P. 41.

[37] This is the stated purpose of HQ-USMC, "Local Command Work Measurement" (Vol I of "Management Improvement Handbook", NAVMC 1088-ADM (Revised), 1954). It suffers from a common failing of Work Measurement Systems by assuming that "output per man" is the only available criterion.

scene is Work Sampling. One or two people in the Planning Division with a basic understanding of the principles underlying statistical sampling and some training in the methods of making random observations and compiling the data gathered would give the maintenance officer a Work Sampling capability.[38] Considering that the present system costs the time of every supervisor in the department, work sampling would be inexpensive and could provide very superior data.

Probably an early objection to this system would be that the data of different maintenance organizations would be impossible to standardize for use by higher authorities. There are two reasons why this objection is irrevelant to the problem. First, the data being produced now by the Manhour Accounting System is useless to authorities higher than the maintenance organization because it is not related to real problems in the organization. Second, standardization between organizations is not an end in itself, but is assumed to contribute to the missions and objectives assigned to subordinate organizations. Maintenance organizations are controlled by an incentive system that operates through the flight

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[38]Heiland and Richardson, op. cit., provides an excellent description of the practical techniques of work sampling.

time objectives assigned to the organization. The organization's interest in a "correct" work study system depends on the utility the organization sees in the system. Standardization does not have value for either the maintenance organization or higher authorities when it does not contribute to flight time objectives.

CHAPTER VII

SUMMARY AND CONCLUSIONS

1. The maintenance Officer interested in improving his organization's output can accomplish this by either increasing his budget of inputs or improving the efficiency of current input use. Because most inputs do not have a later cost to the organization, efforts to increase inputs generally are more rewarding than efforts to increase efficiency. If authorities wish to encourage voluntary increased efficiency in maintenance organizations it is necessary that incentive changes be designed that increase the cost of inputs to the organization. The study of the organization's efficiency, then, involves the study of its incentive system or the structure of its penalties and rewards.

2. The primary positive output of the organization is flight time. Operational command rewards are metered by the organization's success in completing flight time missions. The strength of this incentive generally overwhelms the numerous other special incentive systems pressed on the organization. Special incentives for gains or positive outputs other than flight time become significant only when the organization reaches an extreme position. Organizations adapt to special incentives by diverting

enough of their output to the special objectives to avoid extreme costs and view the possibilities for reward from special incentives as less profitable than flight time gain. Authorities outside the operational chain are in a poor position to reward the organization and must rely on punishment as incentive for special objectives unless they are able to cause the operational chain to build the objectives into its incentive system. Thus, safety records, to which operational commanders generally give close attention, are much more sensitive than enlisted promotion and training records, to which operational commanders give attention only when the organization's performance is extremely poor.

3. The negative consequences, present and future, of using a resource in the current time period are what the organization views as its costs for that resource. Most of the organization's resources are cost free. Some resources are limited, but, since the limited resources cannot be inter-substituted, are still considered free by the organization. Inefficient use of one limited resource does not cost the organization flight time by reducing the available quantity of another limited resource. Using "too many" tow bars does not mean that the organization will have "not enough" jacks or other equipment. Thus, allowance lists remove the organization's incentive for

efficient use of these resources by removing the negative consequences of using them. Other resources such as fuel and repair parts are not limited even by allowance lists. These may be consumed until their marginal contribution to output is zero. What is used during the current time period cannot have a negative consequence in later time periods unless, perversely, "too little" is used currently and this causes later budgets to be reduced.

4. Only one resource, when used, can have later negative consequences, or costs, for the organization and that is its human resources. Increased work hours now can cause reduced effort later, or "too little" training now can prevent increased skill later. If "later" is more than two or three years, the current organization will not view the consequence as a cost since the organization will be dissolved by then, but many human resources costs fall due in less time than this. The military's preoccupation with "leadership" to the exclusion of financial and material management theory is largely explained by recognizing that the military organization's only costs arise from its human resources. It is quite rational, then, that the maintenance officer give extremely close attention to the utilization of personnel and push aside the problem of efficient utilization of other resources.

5. There appear to be two routes to improved efficiency in the maintenance organization:

a. Allow an all-wise "Solomon" to prescribe the exact input of all resources into the organization, the exact method in which they are combined, and the exact output to be expected. This assumes that meaningful exactness is attainable by the "Solomon" in all these things and that subordinate organization managers are able and willing to perform the mechanical function of knowing what they are "supposed to know" and doing what they are "supposed to do" without discretionary variance. This makes the organization manager responsible, not for output or performance, because the "Solomon" controls this, but only for doing what he is told. The application of this concept is marked by an increasingly detailed stream of directives and control mechanisms from the "Solomon", attempting to either explain or eliminate the output variability caused by organizations with human "weaknesses".

b. Design organization incentive systems that align subordinate production input and output costs and gains with higher authority valuations of the same factors. If both evaluate the costs of resources used in the same manner and view objectives in the same way, the problem of subordinate control disappears. The incentive system

itself makes the subordinate his own strongest critic of poor performance. The subordinate organization adapts to changing external conditions more quickly and more accurately than a higher authority can compute a new solution to the same problem. This concept is the familiar argument for making governmental organizations more "business-like" by introducing the "profit motive" to non-market oriented managers.

Both of these routes to improved efficiency have demonstrated weaknesses in application. The "Solomon" never proves to be as wise as necessary and excuses his shortcomings by pointing out the failures of subordinate organizations in following his directions. He invariably has a "poor group" working for him. The "profit-motive" is effective for the production center manager given this incentive, but there are always smaller production centers below this manager which do not have this incentive. A decentralized incentive system may operate to control the Air Group Commander and leave the Air Frames Shop Supervisor under a "Solomon" allocation system. The advantages of decentralization are applicable at all levels, but the lowest level at which it is profitable is exceedingly difficult to define.

6. The previous discussion has not attempted to design an improved incentive system for maintenance

organizations, but only describe the system as it is presently and point out alternate conceptual possibilities. The importance of personnel utilization control to the maintenance officer is evident from the unique character of human resources in the organization. Personnel resources utilization, alone, offers both significant incentive for efficiency and opportunity for decentralized decision making under the present incentive system. The Manhour Accounting System of BUWEPS Instruction 5440.2 is a first attempt to give the maintenance officer a quantitative information system for controlling personnel utilization. It is suggested that:

a. An analysis of the field use of the System will show that is has very little value to maintenance officers. By attempting to report on all possible problem areas, the System fails to give the maintenance officer any useful data.

b. An information system that attempted only to give a technique for work study, leaving problem formulation to the individual maintenance officer, would be considerably more valuable than the present Manhour Accounting System. Industrial Work Sampling is adaptable to most organization sizes and problems. It appears to meet the objective of Manhour Accounting much better than the present system.

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APPENDIX

APPENDIX A

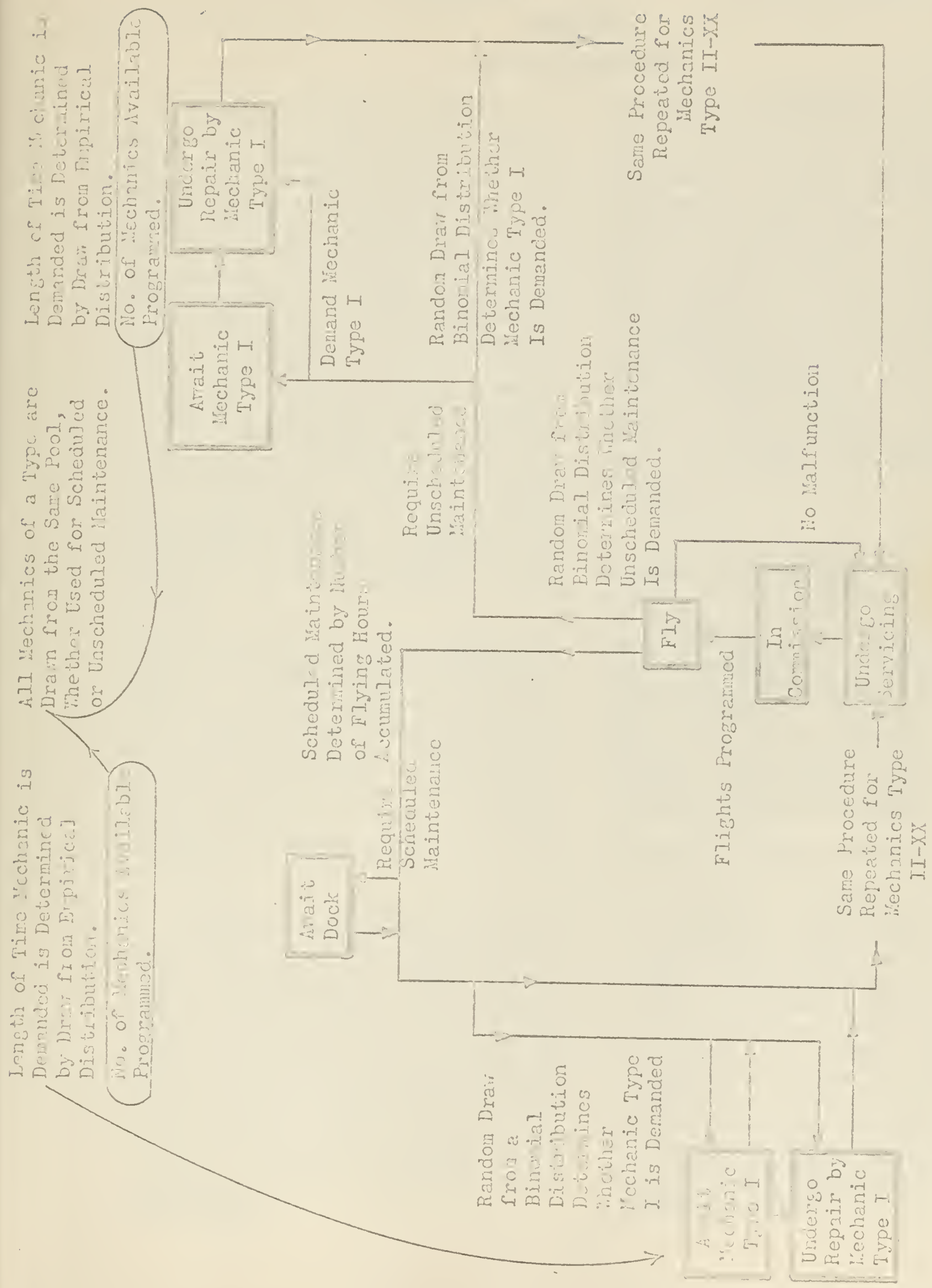

Fig. 1 -- Flow of Aircraft Through Maintenance in Simulation Model

SECTION G

Manhour Accounting

1. PURPOSE. A manhour accounting system is prescribed in this manual in order that the Fleet may realize the maximum benefit from a standard organization. The organization of any enterprise is but one link in the chain of management control necessary to a comprehensive and integrated attack on the causes of waste and ineffectiveness. The manhour accounting system gives the Aircraft Maintenance Officer the facts that he needs to chart his course toward better availability of aircraft at lower costs of operation. Systems to provide a control of manhour expenditure have been strongly recommended by the General Accounting Office and directed by the Department of Defense for many areas of government operations, including maintenance operations. Similar operations in Fleet Aircraft Maintenance Departments are not considered to be an exception.

2. DISCUSSION. The manhour accounting system, described in the following paragraphs, is a technique used to control and forecast personnel utilization. Information obtained through this technique aids in planning and workload scheduling; in manpower distribution; in pointing out time-consuming practices especially in non-productive areas, and in providing a basis for justifying realistic personnel allowances.

In order to control personnel activity, it is necessary to obtain reports relative to all personnel in their daily activities. The reports should cover major manhour areas that are indicative of how the activity's manpower effort is distributed and that are also indicative of the reason for such a distribution. These reports are summarized into a weekly report of hours and percentages showing the distribution of the manhours. Sample summaries are provided to reveal the purposes of the system and their value to all levels of management.

3. DESIGN OF THE SYSTEM. In designing a manhour accounting system to accomplish desired results, the elaborate mechanisms for checks and balances of comprehensive systems for industrial operations have been avoided. Conditions peculiar to the military operation were taken into consideration in this design work along with the need for a maximum of accuracy at a minimum of cost in time in accumulating, reporting and summarizing pertinent information. The system is therefore tailor-made to fit the environment of Fleet Maintenance operations providing a minimum of work categories and a descriptive reporting sequence showing how time was spent in these work categories.

The elements of the system are a description of the significant manhour categories, a simple mechanism to account for non-productive time, a daily report that can be quickly and easily prepared, and a consolidated report that reflects the efforts of the Department on one sheet of paper. Forms to accomplish the objectives of the system include the Daily Check-Out and Check-In Log, the Daily Man-Hour Distribution Report and the Consolidated Manhour Distribution Report.

4. DESCRIPTION OF THE SYSTEM.

a. Definitions of Manhour Categories

Productive Work reflects all time spent accomplishing the mission assigned to the organization. This work can be performed on a hardware item, such as aircraft, or can be performed to support the hardware work. Such support work would be planning, inspection, supervision, etc. The productive categories are defined below.

Shop Maintenance reflects all time spent performing Class "C" and "D" maintenance tasks.

Hangar Maintenance reflects all time spent performing Class "E" maintenance tasks.

Line Maintenance reflects all time spent performing Class "F" maintenance tasks.

Support of Maintenance Work reflects all time spent performing tasks which are non-maintenance but which are in support of the organization's mission. Examples of such work are supervision, planning, inspection, cleaning up shop area, administrative functions, etc. If a function, which is in support of maintenance work, is performed by a man while he is engaged in the performance of a maintenance task, such time is reflected under the maintenance task that he is performing.

Non-Productive Work reflects all time spent during working hours which do not accomplish or support the organization's mission. The time incurred under the Non-Productive Work category is usually time over which the supervisor has no authority or time which the supervisor finds difficult not to grant. A "Check-Out and Check-In Log" should be utilized to account for Non-Productive Work time. The four categories of Non-Productive Work time are defined below:

Delays reflect the idle time incurred awaiting material deliveries, awaiting work, standing-by waiting for aircraft or any other reason that may cause idle time. When time is recorded as a Delay, an entry should be made in the "Check-Out and Check-In Log" even though the man remains in the area.

Military reflects the time incurred because a man was discharging a requirement imposed on him for military reasons. Such time is usually planned and controlled at a level higher than the immediate supervisor and many times higher than the Aircraft Maintenance Officer. The "Check-Out and Check-In Log" is utilized to account for Military time. Examples of such time are listed below:

Watch	Organized athletics
Special Duty	Rating Exams
Personnel Inspection	Training & lecture requirements outside of the Maintenance Department
Muster	
Flying	Working Parties outside Maintenance Department
Discipline	
Courts & Boards	Committee Work (Welfare Committee)
Securing early to go on watch	
Compensatory time off for watch or duty	Details
	Meals

Personal reflects the time incurred for needs personal to the individual. The supervisor, for various reasons, usually finds it difficult not to grant time for the individual to attend to his personal needs. The "Check-Out and Check-In Log" is utilized to account for personal time. Examples of such time are listed below:

Church	Barber Shop
Commissary	Bank
Sick Bay	Navy Exchange
Recreation	Unorganized Athletics
Clothing & Small Stores	

Leave and Special Liberty reflect the time a man spends on Leave or Special Liberty, but only that time which falls during working hours when the entire organization is scheduled to work. When Sunday

routine is observed during normal working hours, the Leave or Special Liberty time falling during that period is used.

b. Daily Check-Out and Check-In Log: The Check-Out and Check-In Log (Figure XIV) is used to account for a man's time when he is in the work area but for some reason is idle. Thus the supervisor is afforded the means to account for a man's whereabouts when he is away from the work area as well as a means to document the non-productive time incurred. The hours recorded in this log for each category are transferred to the Daily Manhour Distribution Report (Figure XV), thus showing the total hours of a full working day. To be effective, this log should be mandatory, which will assure its usage for recording non-productive time.

This log is the responsibility of the supervisor responsible for authorizing absences. He requires the individual to fill in the log when the individual leaves the work area or when the individual becomes idle, under the definition of delays. Such entries are made by the man only through the "time-in" column. The supervisor extends all elapsed times to the proper non-productive columns. For leave or special liberty, the supervisor makes the entries. Whenever a substantial portion of the personnel are in a non-productive status during the same interval and for the same reason, the supervisor makes the entry for the group showing the number of men involved in lieu of names. The extension to the proper column is a combined figure. For example, if ten men are involved and the elapsed time is 15 minutes, the elapsed time extended is 10 X 15, equivalent to 2 hours 30 minutes.

c. Daily Manhour Distribution Report. Daily Manhour Distribution Reports (Figure XV) are prepared each day and submitted to the Planning Division where all reports are compiled into a management report as required by the Aircraft Maintenance Officer. The echelon responsible for preparing this report should be that organization level where the Check-Out and Check-In Log is maintained. The information for the Daily Manhour Distribution Report can be obtained from the suggested Check-Out and Check-In Log, Work Orders, and various other forms available to the supervisor. Group time is entered on this report as line entry below the names. It is important that the supervisor responsible for this report insures that the total time recorded equals the number of hours which are available to the activity for a work day. For example, if the work day is from 0800 to 1600, and there are ten men assigned, then the total hours for a work day is eighty. A separate report should be submitted for those people required to work after normal working hours. If utilized properly, this report can be very beneficial to the supervisor since he will see documented evidence as to how his available manhours were utilized. Knowing what is absorbing his manhours, such as military time, the supervisor would be able to prove that his work effort would be higher if he had less interference from outside sources.

d. Consolidated Manhour Distribution Report. The Consolidated Manhour Distribution Report (Figure XVI) serves as a management tool to give the Aircraft Maintenance Officer, his subordinates, and his superiors an insight as to where the time of the personnel of the Aircraft Maintenance Department has been expended. This report has been designed to realistically portray conditions as they exist. It indicates "trouble areas" and can be the basis for corrective action. Furthermore analysis of comparable reports, allows the Aircraft Maintenance Officer to establish direct manhour goals or standards which he might consider desirable.

This report is intended to be flexible in that the work categories can be increased or condensed depending on needs of the Aircraft Maintenance Officer. As an example, the Consolidated Manhour Distribution Report may indicate that much non-productive time is spent for personal reasons. It is possible to sub-divide the

DAILY CHECK-OUT AND CHECK-IN LOG

DIVISION	BRANCH	SECTION	DATE
300	301	311	15 AUGUST 1958

NAME	REASON	TIME OUT	TIME IN	DELAYS	MILITARY	PERSONAL	LEAVE OR SL
Group - 9 men	MUSTER	0800	0815		2:15		
A.B. SMITH	Awaiting Material	0825	0900	:35			
J.M. MORRIS	LEAVE	0800	1600				8:00
A.V. BEE	Sick Bay	0830	0945			1:15	
R.J. BROWN	MORALE LECTURE	1000	1100		1:00		
J.P. MANNING	BANK	1005	1115			1:10	
Group - 4 men	NOON MEAL	1100	1200		4:00		
Group - 5 men	NOON MEAL	1200	1300		5:00		
Group - 9 men	MUSTER	1300	1315		2:15		
D.E. FOY	EMERGENCY LEAVE	1400	1600				2:00

Figure XIV

DAILY MAN-HOUR DISTRIBUTION REPORT

TO: Planning Division   DATE OF REPORT: 15 AUGUST 1958

FROM (Division)	(Branch)	(Section)
300	310	311

NAMES OF MEN ASSIGNED	RATE	PRODUCTIVE				NON-PRODUCTIVE				TOTAL MAN-HOURS
		SHOP	HANGAR	LINE	SUPPORT	DELAYS	MILITARY	PERSONAL	LEAVE AND SPECIAL LIBERTY	
A.V. BEE	ADC				6:30					6:30
A.B. SMITH	AD1C	5:00		1:05		:25				6:30
R.L. JOHNSON	AD1C								8:00	8:00
T.R. CALAHAN	AD2C	6:30								6:30
H.S. BOYER	AD2C	5:15						1:15		6:30
C.L. BLACK	AD3C	6:30								6:30
S.N. ANDERSON	AD3C	4:30							2:00	6:30
M.B. O'TOOLE	ADAN	4:00	1:30				1:00			6:30
H.D. HALL	ADAN			6:30						6:30
O.R. THOMPSON	ADAN	1:50	3:30					1:10		6:30
Group - Muster							4:30			4:30
Group - NOON MEAL							9:00			9:00
TOTAL MAN-HOUR DISTRIBUTION		33:35	5:00	7:35	6:30	:25	14:30	2:25	10:00	80:00

SIGNATURE OF SUPERVISOR: A. V. Bee   DATE: 16 August 1958

Figure XV

"personal" work categories by subtitles such as church, commissary, bank, barber shop, etc. in order that more precise information may be furnished so that corrective action might ultimately be taken.

5. RESULTS FROM THE SYSTEM. It is desirable for the Aircraft Maintenance Officer to have complete control over the conduct of work operations and the regulation of work performance at subordinate management levels in accord with his mission and objectives. The Consolidated Manhour Distribution Report acts as a starting point in that it tells how many direct hours of work were expended. The next step for him is to develop a production type report stating what was produced for the hours spent. This becomes com plicated in a Maintenance Department Activity since most of the work is in the nature of servicing, checking and adjusting and cannot be associated with a product. In cases like this, however, it is possible to compare direct manhours spent on shop, hangar, and line functions with certain available flying data in order to determine correlations between them. As an example, if direct hours by maintenance functions were graphed on a chart with flying data such as number of flying hours, number of flights and the number of aircraft in custody of the activity, it might show that there is a direct relationship between the number of flights and the number of direct hours of line maintenance. If such a relationship continued to be constant, the Aircraft Maintenance Officer could determine how many people should work on line maintenance each day depending on the number of flights to be flown. He could also establish a standard of work performance on "direct hours line maintenance per aircraft flight" by which he could measure future work performance.

6. SUMMARY. It is recognized that the proposed manhour accounting system fills only a part of the requirements for effective management of an aircraft maintenance department. Additional techniques need to be developed to supplement the information generated from manhour accounting. Until formalized techniques are issued, Aircraft Maintenance Officers are urged to utilize the manhour information, available through the above described system, in showing correlations between utilization of maintenance manhours and a related operating program. Such correlations will be very beneficial in workload scheduling, redistribution of manpower effort, and in providing accurate justifications for other management decisions. In summary, manhour accounting is another step towards furnishing the Aircraft Maintenance Officer with information to aid him in his job of assuring adequate aircraft maintenance.

CONSOLIDATED MAN-HOUR DISTRIBUTION REPORT

ACTIVITY: VA-75 REPORT PERIOD: 4 AUGUST 1958 - 8 AUGUST 1958

NO. MEN ASSIGNED	TAD OUT	TAD IN	AVAILABLE MANPOWER		HOURS PER WORK PERIOD		AVAILABLE HOURS
104	4	0	100	x	40	=	4000

	MAN-HOUR DISTRIBUTION	TOTAL ACTIVITY		DIVISIONS									
				100 PLANNING		200 QUALITY CONTROL		300 SHOPS		400 HANGAR		500 LINE	
		HOURS	%	HOURS	%	HOURS	%	HOURS	%	HOURS	%	HOURS	%
PRODUCTIVE MAN-HOURS	SHOP	500	12.5					500	46.3				
	HANGAR	693	17.3					60	5.6	607	43.3	26	2.6
	LINE	562	14.1							78	5.6	484	48.4
	SUPPORT	308	7.7	222	55.5	86	71.7						
	TOTAL PRODUCTIVE MAN-HOURS	2063	51.6	222	55.5	86	71.7	560	51.9	685	48.9	510	51.0
NON-PRODUCTIVE MAN-HOURS	DELAYS.	80	2.0	0	0	0	0	20	1.8	42	3.0	18	1.8
	MILITARY	819	20.5	101	25.3	23	19.2	200	18.5	258	18.4	237	23.7
	PERSONAL	625	15.6	37	9.2	11	9.1	180	16.7	255	18.2	142	14.2
	LEAVE AND SPECIAL LIBERTY	413	10.3	40	10.0	0	0	120	11.1	160	11.5	93	9.3
	TOTAL NON-PRODUCTIVE MAN-HOURS	1937	48.4	178	44.5	34	28.3	520	48.1	715	51.1	490	49.0
	TOTAL MAN-HOURS	4000	100.0	400	100.0	120	100.0	1080	100.0	1400	100.0	1000	100.0

Figure XVI

APPENDIX C

A Criticism of the Manhour Accounting System of BUWEPS Instruction 5440.2

The Manhour Accounting System of BUWEPS Instruction 5440.2 was introduced as a preliminary effort to give the aircraft maintenance officer a tool for work analysis. Its technique and objectives were tentative and incomplete. The announced objectives of the system were only vaguely considered in the hope that experience with it would sharpen both technique and objectives.[39] This has not occurred. The system has hardened into the abortive form first prescribed in 1958. This form can be criticized from several aspects:

System Objectives. The only specific objective that 5440.2 announces for the system is to quiet a complaint from the General Accounting Office that aviation maintenance activities do not have any method for estimating the degree of utilization of personnel.[40] This objective had a very strong influence on the design of the system. The system uses the accoutant's approach of recording

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[39]Bureau of Naval Weapons Instruction 5440.2 dated 23 September, 1958. p.1.

[40]Ibid., p. 45.

one hundred percent of all personnel time in rigid, predetermined categories, in the manner of recording expenditures against appropriation accounts. The information needs of the unit manager require less detail than this and much more flexibility. Information categories such as "military time", over which the manager has little control, require the same effort of data collection and computation that critically important categories such as "delay time" require. Many wasteful hours are spent by Planning Division personnel trying to balance, exactly, the individual shop reports against total manhours available during a reporting period. For purposes of control the manager is not interested in a definitive accounting of every last working hour available to him; he could not act on such extremely accurate information. He is interested in trends and significant changes in his operations. The approach of the statitician is more fruitful for control purposes than the approach of the accountant.[41]

Any system design suffers from a failure to adequately consider the system's objectives and Manhour Accounting is no exception. Instruction 5440.2 vaguely says that much useful data is made available, but does not approach the

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[41] Arthur Smithies, The _Budgetary Process in the United States_ (New York: McGraw-Hill Book Company, 1955), p. 158.

problem of how to use the data. Is 65% "productive time" good or bad? If bad, how can it be improved? Where do you look for possible improvements? These questions and many others arise for the manager when he is confronted with the Summary Sheet at the end of an accounting period. Systems design should start with specific questions to be answered and then move to techniques for getting answers to these questions. Manhour Accounting appears to have been hatched from a feeling that some sort of work measurement system was needed, but the particular needs of individual managers were so varied that they could not be considered in the system design. An information system that does not answer specific questions must be generating at least some useless information. If a work measurement system is to be useful to a unit's management it must consider that particular management's objectives for the system. This means that it is patently impossible to design a work measurement system that will be universally useful to all unit managements.

Inaccuracy of Data. Manhour Accounting uses shop supervisors to record the activities of personnel by the categories of "productive" and "non-productive" time. This technique produces errors in the basic data from which manhour summaries are compiled. First, a bias error is introduced because the shop supervisor has an interest

in causing his reports to stay in line with the reports from other shops. It is difficult to convince a supervisor that a significant change in the percent of productive time he reports will not reflect unfavorably on his performance. Since he cannot record all personnel time as it occurs, most of the data recorded by the supervisor is from memory at the end of the day, according to his judgement of how his people were used that day. The supervisor, no matter how conscientious he may be about the accuracy of his report, cannot avoid having his judgement affected by his knowledge of past reports and percentages reported by other supervisors. This subtle influence on all supervisors in the unit has the effect of tending all utilization percentages toward constant figures and dulling the sensitivity of manhour reports to changes that occur within the unit. Since sensitivity to changes is precisely what the manager requires for control purposes, the usefulness of the system is questionable.

The other major source of error in data is the technique for gathering the data. Instruction 5440.2 prescribes check-out, check-in forms for recording the time personnel are out of the area, along with the purpose for being out of the area. Reliable information requires that these forms be used faithfully by all personnel,

without exception. Any large group of people can be relied upon <ins>not</ins> to be faithful in observing such a requirement without tight controls. Controls mean more time and effort by other people that are also liable for errors, so that the question of whether the value of the system is worth its cost arises very quickly. The categories of work effort other than "out-of-area", such as "productive hanger", "line", "supervision", etc., time, are recorded by the shop supervisor in summary form, usually at the end of the day. In addition to the bias that this introduces, as discussed above, the possibility for error in estimating actual time spent in each category is considerable. In addition, there is no method available for estimating the magnitude of the error. These two sources of error, bias toward insensitive data and inaccuracies in data gathering, leave the manager with an information system that he knows is not precisely correct, though the language of its reports pretends to be, and he is unable to estimate the degree of inaccuracy in his information.

<ins>System Cost</ins>. The cost of Manhour Accounting can be measured by the time supervisors spend gathering and compiling data. From the point of view of salary or value to the mission of the unit, supervisor time is the most expensive personnel cost the unit has. If we assume that shop supervisors spend an average of half an hour per day or

two hours per week, each, with their reports, the unit with ten to fifteen supervisors is paying twenty plus hours per week of prime supervisor time for the doubtful information of Manhour Accounting. An additional unmeasurable cost of the system is its effect on supervisor's morale and productivity. Many units find that shop supervisors are not particularly keen on the value of the system and their part in evaluating their own performance. The moral problem of self interest versus honest reporting caused by the system is resented by many supervisors.

Managerial Utility of the Data Generated. A useful work measurement system should operate to highlight exceptional situations in the unit's structure. An operation that is under control requires little of the manager's attention; the manager is interested in knowing where his operation is out of control. This is the familiar principle of management by exception. To adapt this principle to an information system, the system must be designed to optimize its sensitivity to change and rapidly bring managerial attention to change as it occurs. Manhour Accounting can be criticized as insensitive in two respects. First, the bias of shop supervisors that tends to cause basic data from all shops to read the same, as discussed earlier. Secondly, the form of reporting used by the system makes changes difficult to spot. Individual shops usually

summarize their data weekly and these summaries are used to compile the monthly report that is routed to unit managers. Any significant variations in productive time, or any of the other categories of shop time, that occurred during the month are usually hidden by the long time covered by the report. The unit could have experienced considerable fluctuation in productive time,both high and low, but the monthly average would not even hint at this. Additionally, the monthly report compiles its category percentages by very large unit subdivisions. An "average" non-productive time figure for the Hanger Division can conceal significant differences between the Power Plants, Airframes, and Avionics shops. Any operation can be made to appear stable and uniform if large enough groups are measured over long enough time periods.

Finally, the method of presenting data to managers for analysis tends to obscure changes as they occur over time. On a line with each unit subdivision are listed the manhours that subdivision spent in each category of productive and non-productive time, along with the percentage figure that time represents of the subdivision's total time. Only information of the current month is presented on the report, which means that reports of previous months must be removed from the files in order to analyse changes or any trends that might be developing. This requires an item by item check; significant information is not immediately obvious.

APPENDIX D

The Objectives of Personnel Information Systems

The problem of adequate criteria for setting up useful information systems has bothered industrial psychologists as well as economists.[42] The difference in interest of the two schools has implications for the maintenance officer. Whereas the economist is looking for criteria that directly relate to the <u>organization's</u> productive output, the personnel expert is interested in optimizing.the "goodness or worth of the individual <u>members</u> of the organization. The latter approach assumes that the individual productivity of workders can be increased by training, selection, and placement procedures, and other human relations techniques, and proper criteria for measuring this increase are indices such as efficiency ratings, individual production records, number of lines typed per hour, number of errors per day, and number of pieces produced per day.[43]This type of data has obvious usefulness for evaluation of worker performance

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[42]Roger Bellows, Third edition, *Psychology of Personnel in Business and Industry* (Prentice-Hal, Inc., Englewood Cliffs, New Jersey, 1961), p. 353.

[43]*Ibid*.

and promotion potential. Very often, wage scales, piece rate pay, and low-level promotions are tied directly to this type of criteria. But a major failing of this approach to personnel information system design is that, like suboptimization in general, it often is incompatible with or insensitive to higher level objectives. For instance, one worker may have a superior production output record but achieve the record at the expense of the quality of his work, or, because of his personality, prevent other workers around him from producing at their best rate. "Spillover" effects of limited criteria can cause the organization to be supporting a system that contributes nothing to its total output. A second common error of criteria choice, insensitivity to higher level objectives, also is common in human relations information systems. In an attempt to prevent spillover effects, often criteria such as supervisor ratings or "overall merit" ratings are used to attempt to measure the sum contribution of the individual to the organization. Relying on the judgement of supervisors or peers, the assumption is made that the organization's output or success correlate with these judgements. If this were true, total output would rise and fall, everything else being equal, as the average of the ratings of all workers rose or fell. Directors of personnel merit rating systems, however, do

not even attempt to correlate their rating data with higher level criteria such as organizational profitability.

The Navy personnel evaluation and advancement philosophy graphicly illustrates the objectives of most personnel programs. The administration of the Navy's personnel promotion and performance evaluation system is independed of other systems for evaluating and measuring the output or effectiveness of organizations. The individual's performance evaluation or promotion is insulated from the performance of his organization. In effect, the individual is responsible for his own performance but is not penalized or rewarded for the total effectiveness of his organization. Additionally, Navy personnel evaluation attempts to recognize contributions the individual makes that do not aid his particular organization, but rather contribute to larger objectives of the Navy or the national interest. Recognition of civic activity, longevity, and medals and awards are examples of this. In short, the objective of the Navy's personnel evaluation and promotion system is to identify and promote individuals in an equitable manner that will serve the long run, larger interests of the Navy. But, it is a waste of time to attempt to use this system to evaluate the utilization of personnel toward measurable, immediate organizational objectives.